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BRIDGE SCOUR MONITORING SYSTEM AND PROCESS

FIELD OF THE INVENTION

The present invention relates generally to bridge safety especially regarding scour critical bridges. The present invention relates more particularly to the collecting of data and presenting that data to professionals in an interactive manner. With this information, the professionals may quickly ascertain the issues and dangers for specific bridges and make timely, informed decisions regarding measures to be taken to ensure bridge, public and environment safety without undue risk or inconvenience to the public.

BACKGROUND

Bridge failures and other such infrastructure problems in general, some catastrophic, have been occurring regularly over the years. Many of these events were unexpected and resulted in inconvenience to travelers, expense to the public, destruction of property and even deaths.

There is a continuing need to anticipate and forestall these problems. A solution requires upgrading the nature, quantity, and quality of the relevant data. Up-to-date and real time data needs to be collected and quickly and logically presented, along with the historical and previously collected data, to those professionals that are trained and equipped and with the authority to recommend and/or take corrective actions. The information must allow the professionals to identify, prioritize and determine measures to meet the events. These corrective measures may include physical inspection, closing of bridges to traffic and or repair or replacement of the bridges in question.

It is an object of the present invention to gather, evaluate and present data in a coordinated manner to allow qualified professionals to evaluate, prioritize, and determine the appropriate actions required.

SUMMARY OF THE INVENTION

The above objects are met in a system and method with means for measuring real time data from a bridge and the local environment. The data is collected and relayed via a communications network to a central site. The historical and analytical information concerning the bridge are stored in a relational database and presented to the personnel at the central site in a coordinated manner with the real time data. Thresholds are established for any relevant monitored parameter and when any such threshold is reached the system will send a prioritized notice to the central site. The central site allows the personnel to view the location and the surrounding water ways and other bridges and the local population density. The threshold information is presented including data as measured over time and normal levels. The location includes maps of the area that are interactive with the personnel so that the order of the maps being presented can be altered by the personnel. The system is connected to a communications network that may be the Internet or a local network with a portal to the Internet, or groups of networks and redundant computer systems and/or networks, as known in the art. The system provides inter-active pages and software that routinely interrogates Web and other sites for collecting relevant data. Such interrogation may be programmed on a time basis, or an event basis, or some other such criterion as is known in the art.

Other objects, features and advantages will be apparent from the following detailed description of preferred embodiments thereof taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a block diagram of a preferred embodiment of the invention.

FIGURES 2-6 are sequential presentation screens with maps indicating that a threshold is triggered followed by more detailed information and maps.

FIGURE 7 is a web page for the system.

DESCRIPTION OF PREFERRED EMBODIMENTS

The above objects are met in a system designed to have a functionally central (it could be physically distributed) relational database. This database is typically stored in a secure computer system, that is backed-up off-line to ensure preservation of the data. In a preferred embodiment there is a database server that uses a 128 bit encryption web browser. The encryption may be of the public/private key type, private key only type, or other such encryption means and key bit widths that are known in the art. The system is connected to a communications network that may be the Internet or a local network with a portal to the Internet, or groups of networks and redundant computer systems and/or networks, as known in the art.

Figure 1 is a block diagram of a preferred embodiment of the inventive system and represents a central system computer or a distributed computer system, or the like where the database resides. There are means for connecting to communications networks both local and the Internet. Although not shown the system may interact with other systems and servers to share data, for example, with relevant federal agencies.

Figure 1, section B, represents the database of information related to specific bridges. Included in this information is the historical data for each bridge under Archive, including prior events and the time frame of these events. The most recent data from monitors is stored under BIS (bridge information system) and the weather and water conditions expected for the bridge to experience under the GIS (geographic information system). The historical data may contain original specifications of a bridge itself, inspection reports, as well as the occurrence and type of events that have occurred regarding the bridge. Form the known parameters of the bridge and the expected environmental conditions that the bridge might experience, its environment and other factors including human populations and possible damage costs, threshold are established that cover a wide variety of possible

happenings. These thresholds are established, in a preferred embodiment, for virtually any condition and parameter measured that would signal a condition requiring human intervention. In a preferred embodiment, these thresholds are prioritized, and the entity being signaled can be established and may depend upon the type and extent of threshold being exceeded.

Referring to Figure 1, section A, relevant data is routinely collected via a program, referred to herein as Web-Robots, and assimilated into the database. This data includes, but is not limited to, data from: The National Oceanic and Atmospheric Administration (NOAA), the National Weather Service (NWS), the U.S. Geological Survey (USGS), Real time radar data and data collected and evaluated from physical sensors and other such monitoring devices. Such devices may include river gauges measuring depth and flow rates, sliding collars, and other such devices that may directly measure structural parameters on the bridge, like strain gauges, deflection meters, current traffic, and even relevant parameters regarding the local environs. Such devices may be battery powered or directly connected to power sources so that real-time data may be remotely monitored via the Internet. Other data may be collected from such devices by hand or by human measurements and input into the system.

The above and other data may be used to identify conditions that may result in severe flooding or other water-related catastrophic events.

The system software, schematically shown as 10 of Figure 1, runs the entirety of the system may be known software, including operating systems and languages. However, this software may be distributed and operate via known communications channels. For example, Windows NT, Windows 98, Mac, Unix and many other such operating systems are known in the art. Java, HTML, PERL, C++ and other such languages may be used with the appropriate compilers, assemblers, servers, etc. As known in the art, such known programs and languages may be used to build the entire system in many possible configurations. In a like manner, the system hardware, represented as section D in Figure 1, includes computers, communications, local networks, modems, memories, etc. may be

assembled and built from known sources including IBM, Dell, Apple, Hewlett-Packard, EMC, Compaq, etc.

The operation of the system, in a preferred embodiment, will analyze the data and observations against thresholds, that when exceeded, cause an alert to be output to humans and/or to other systems. Such thresholds may be arranged into priority levels and alarms. For example, numerical thresholds for scour are resident in the system and implemented as determined by Federally mandated Scour evaluation programs. Still referring to Figure 1, section C, the system outputs automatic alerts to the Department of Transportation (DOT) personnel when thresholds are exceeded. Such

alerts may be transmitted via telephone, cell phone, beeper, or equivalent means to inform those knowledgeable people capable of technically evaluating and responding to critical issues needing immediate attention. The DOT personnel can log onto the system to remotely review the information and data. In a preferred embodiment, the data is present as shown in the Figures appended to this application. The personnel are those that have the background, training and understanding to respond to the wide variety of circumstances that may occur. For example, such personnel would include, but not be limited to, DOT, police, fire department, highway or throughway, local, state, county, and other federal personnel. For security, passwords and the like are built into the system so that only those trained professionals will be able to enter the system and review the data.

In one preferred embodiment, the inventive system provides the DOT Bridge Management Engineers to monitor the national bridge infrastructure for potential scour events with real time hydrologic and weather information. In a preferred embodiment and as described above, the system uses an encrypted 128 bit web browser with Active Server Pages (ASP's) and software (Web Robots) that allows interrogation of the system. Typically the Internet is the communications network of choice, and the system is organized by and for each of the States in the United States. The system runs on localized state server which may be redundant. A federal server may be enabled to access the individual state servers with appropriate security systems in place.

The system collects and evaluates data and relevant information from the various sources listed above and along with the monitored real time data from the Web Robots identifies flooding or other weather related catastrophic possibilities. Such possibilities can be automatically reported to the proper authorities.

The inventive system also allows simulation of catastrophic events so that personnel can be trained and reaction times and proper communications to the proper personnel can be reviewed for quality and timeliness.

The inventive system also will provide a list of scour critical bridges that may be affected by some critical event. The system would alert the DOT personnel via cellular phone, beeper, fax or the Internet that they should personally monitor the event. In some instances bridge safety inspectors or other empowered personal can be notified when catastrophic events require closing of bridges or other such extreme actions. As described above real time and historical along with bridge construction and prior events experienced by bridges are readily available to the monitoring personnel.

In a preferred embodiment, a DOT engineer may be notified by beeper of a scour critical event and the engineer has logged on to the Internet and the inventive system using the proper security passwords and any other such codes. The engineer will identify the threshold being exceeded an the event. The engineer will be presented with a map, for example, of Rhode Island (R.I.) as shown in Figure 2. The left map of R.I. is divided into six quadrants as shown in Figure 3.

Referring to Figure 3, in the top middle bridges that experience events that occur typically every 10, 50, 100, or 500 years are color coded (not shown in color) onto the map. A "watch list" is created from the scour critical bridges in the quadrants and are listed in the event classifications by bridge number. The engineer can focus on a manageable group of bridges as shown in Figure 4. The scour critical bridges in this quadrant are marked by a red dot. The engineer can see the current precipitation via radar in the affected area with the mouse/cursor. In this preferred embodiment, an overlay, Figure 5, is presented with the precipitation data.

The engineer can view the weather information and the affected bridges sorted against the "watch list." The engineer can sort the list by bridge type, bridge function (railroad or road way, etc.) and determine which bridges are most critical. In this preferred embodiment these operations are accomplished by pointing and "clicking" with the mouse at a terminal. By clicking on the bridge number or location on a map the engineer is provided with the bridge specific information, including all the data concerning

the bridge (such as, but not limited to, structure type, length, breadth, function, year built, number and type of gauges attached, prior events, etc.) including a map, for example the map of Figure 6. The bridge is identified and alternate routes are highlighted. Using the buttons shown at the bottom of Figure 6. These buttons provide the engineer with information to help the engineer's review of the event happening.

The "Toggle Radar" allows the engineer to obtain the radar weather. The "Search for Bridge" allows the engineer to select a bridge and find its location on the map. The "Sort List" allows the engineer, as mentioned above, to sort any particular bridge against the "watch list." The "Bridge History" allow the engineer to access the historical data regarding the bridge as described above. Also, as described above the engineer can view the real time gauge data and compare that data to the expected readings. As shown in Figure 6, a 50 year Precipitation event for a particular bridge and relevant bridge data is listed. From the inventive system the engineer can report and recommend actions. Those actions can be prioritized and might include physical inspection of the bridge, closure of sections of the bridge and/or re-routing of traffic. The engineer can edit and then submit his report by clicking, as known in the art. The report form presented to the engineer by the system may have boxes to be checked for channeling the information to the proper authorities. The report will be a record and a means for communication for inspectors, engineers and for management. The report may be accessible from several locations in real time provides a means for real time information to be passed and for timely decisions and actions to be taken.

It will now be apparent to those skilled in the art that other embodiments, improvements, details and uses can be made consistent with the letter and spirit of the foregoing disclosure and within the scope of this patent, which is limited only by the following claims, construed in accordance with the patent law, including the doctrine of equivalents.

ADDENDUM: SCOURWATCH.

ScourWatch is an internet-based bridge scour monitoring software product that provides Department of Transportation (DOT) Bridge Management Engineers with real-time internet hydrologic and weather information to allow them to monitor scour on the U.S. bridge population. The system notifies DOT Engineers in the advent of bridge-scour critical event. Bridge Engineers will be able to remotely access ***ScourWatch*** and report events in real-time using the system on-site with a laptop and cellular modem. The program's database will archive any pertinent bridge information for historical analysis and/or emergency scour-event simulation.

Architecture:

- The system will be created with a relational database as the core software agent. ***ScourWatch*** will utilize a 128 bit encrypted web browser with Active Server Pages (ASPs) and Web Robots. The entirely internet-enabled software will be designed to run on a localized state computer server. A state may decide to have multiple computer servers on multiple sights in order to achieve redundancy. A federal computer server may be enabled to access individual state information through the Internet via a state provided security code.

System Operation (Figure1):

- The ***ScourWatch*** system (Figure 1:D) identifies the occurrence of any severe flooding condition or any other water-related catastrophic event by collecting relevant bridge information from sources such as: *National Oceanic and Atmospheric Administration (NOAA), National Weather Service(NWS), US Geological Survey(USGS)* and any bridge scour monitoring device data available (river gauges, sonic fathometers, and sliding collars) **(Figure1: A).** Web Robots are employed to pull relevant information from these internet sources.

- ***ScourWatch*** produces a list of scour-critical bridges based on federally mandated numerical thresholds for scour. It alerts DOT personnel via cellular phone, beeper, or fax that they need to log into the ***ScourWatch*** system with a security code to view the potentially critical bridges so emergency crews can be notified and/or bridges can be closed to save lives **(Figure 1:C)**. The bridge list can be sorted by importance for critical scour attributes. All events and bridge information are archived in the ***ScourWatch*** database for historical and training purposes **(Figure 1:B)**. DOT Engineers can report on-site evaluations through the use of HTML enabled

reports that can be sent to email addresses, fax machines, and other text communication devices **(Figure 1:C to Figure 1:D to Figure 1:E)**.

Typical Practical Application (Figures 2-6)

- A DOT Engineer has been notified of an scour-critical event by beeper and has logged on to the Internet and the ***ScourWatch*** system. He or she is presented with a full scale map of a state (RI in this demo) on the left, divided into six quadrants. The Engineer selects the upper-left quadrant for a detailed area view; which appears to the right of the state map. A list of color-coded event classifications appear in the top middle portion (10, 50, 100, and 500 year events) and are reflected by a specific color haze on the larger map's quadrants. For demo purposes the upper and bottom left have scour events taking place. The corresponding scour critical bridges in those quadrants appear under the event classifications by bridge number **(Figure 2)**.

- The Engineer will want to see the current precipitation in the affected area, so he/she places a mouse cursor over "Toggle Radar," a button under the main state map. Real-time radar precipitation information is displayed in a colored, semi-transparent layer over both the state and the detailed map **(Figure 3)**.

- After viewing weather information to determine the severity of the storm, the Engineer will want to study the affected bridges; which are listed by importance and colored to correspond to the color of the event classfication (10, 50 ,100 , and 500 year events). The appropriate bridge number is clicked with a mouse, and the Engineer now provided with bridge-specific information (such as structure type, year built, number of gages attached) and a magnified map (bridge indicated by a red dot). ***ScourWatch*** users can also click their mouse on additional buttons to provide specific information such as: "Search for Bridges," "Bridge History," "Sort List." Two more buttons appear below the magnified map: "View Gauge" and "View Report" **(Figure 4)**.

- The "View Gauge" button allows the Engineer to witness real-time data from the corresponding river gauges communicated to satellites or monitoring stations along the river **(Figure 5)**.

- Finally, the Engineer will ~~have~~ be able to submit a report by clicking "View Report" and filling in the appropriate boxes and channeling the information to the proper authorities **(Figure 6)**. C Paul